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ORIGINAL ARTICLE

Factors That Influence Functional Mobility Outcomes of Patients After Traumatic Brain Injury

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KEYWORDS
functional mobility;
Glasgow Coma Scale;
modified Mini Mental State Examination;
Rivermead Mobility Index;
traumatic brain injury

Summary *Objective/Background:* The consequences of traumatic brain injury (TBI) include physical, cognitive, psychological, behavioural, and emotional deficits. Prognostic factors such as age, mechanism of injury, and severity of injury assist in determining the outcome of the patient. It is believed that predictors of recovery assist both the patient as well as family members in determining the potential outcomes for the patient. The objective of this study was to identify factors that influence functional mobility outcome of patients after TBI.
Methods: This was a cross-sectional study. Participants were assessed predischarge. The Glasgow Coma Scale on admission was noted to establish the severity of the TBI. The Rivermead Mobility Index was used to establish the functional mobility outcome.
Results: The sample consisted of 60 participants of which 56 (93%) were males. The average age of the participants in the study was 28 $\pm$ 8.5 years. More than 50% of the participants were unable to walk outside and 37% were able to climb a flight of stairs without help at the time of discharge from the hospital. Younger age ($p < .001$), male gender ($p = .001$), Grade 12 education ($p = .001$), being self employed ($p < .001$), having bowel and bladder continence ($p < .001$), not smoking and drinking ($p < .001$), and having occupational therapy sessions ($p = .002$) had a positive impact on function after TBI.
Conclusion: Previous studies have identified a multitude of factors and this study has served to confirm factors that have a positive impact on physical function after TBI within this study group.

Introduction

Traumatic brain injury (TBI) is a major cause of disability, morbidity, and mortality and is responsible for a significant proportion of all traumatic deaths in the USA (Bruns & Hauser, 2003). In South Africa, the incidence of TBI was reported to be 360/100,000, and the causes were mainly interpersonal violence and motor vehicle accidents (Bruns

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& Hauser, 2003). Assault is also one of the leading causes of TBI, especially in the lower socio-economic groups and in war-torn countries (Chua, Ng, Yap, & Bok, 2007).

Closed TBI is one of the leading causes of death or permanent disability, whereas open traumatic brain injuries usually results in focal damage to the cerebrum (Grados, Slomine, Gerring, Vasa, Bryan, & Denckla, 2001). Traumatic brain injury results in the disruption of neuronal activity as well as changes in oxidative metabolism and blood within the brain (Grealy, Johnson, & Rushton, 1999). Thus, the consequences of TBI are vast and may include physical, cognitive, psychological, behavioural, as well as emotional deficits (Chua et al., 2007).

People with TBI injury may also present with a wide range of motor as well as sensory deficits, extra pyramidal symptoms, dystonia, and spasticity, which influence functional outcome (Chua et al., 2007). Furthermore, major problems in the central nervous system may include motor programmes that are either ineffective or absent, impaired motor memory (especially for motor sequences and postural alignment), impaired feedback and feed forward mechanisms, ataxia, dysmetria, dysdiadochokinesis, and intention tremor (Hillier, Sharpe, & Metzer, 1997).

Diffuse axonal injuries were found to result in the greatest disability, especially in the areas of activities of daily living and ambulation (Englander, Cifu, Wright, & Black, 2003). Dickinson, Bunn, Wentz, Edwards, and Roberts (2000) also found that 79% experienced headaches, 59% had problems with memory, and 34% were unemployed 3 months after sustaining the TBI, thus affecting their social functioning.

Most studies on TBI injury research focus on factors related to the acute medical and surgical severity (Finch, Sandel, Spetell, Mack, & Spivack, 1997). Further information is required to provide patients and their families with a better understanding of their prognosis as well as to determine the global outcome of the patient (Englander et al., 2003). Preinjury factors associated with poorer outcome after TBI include: older age, history of previous head injury, alcohol abuse, lower socio-economic and educational status (Chua et al., 2007). This study was undertaken to determine the functional mobility outcome and the factors that influence it post-TBI at the time of discharge from the hospital.

Methods

This was a cross-sectional study. Ethical clearance was obtained from the University of the Witwatersrand Ethics Committee for Research on Human Subjects and permission was granted by the authorities at the data collection sites (hospitals). Participants for the study were recruited from three hospitals in the Johannesburg area and were identified through screening of patients in the neurology wards by the physiotherapists who worked in these wards. Participants had to meet the following eligibility criteria: (a) sustained TBI as evidenced by a loss of consciousness or by post-traumatic amnesia; (b) have neurological fallout; (c) have no other medical condition that may affect functional mobility; (d) be medically stable at the time of physical assessment; and (e) be able to sign informed consent forms or have a relative who could sign informed consent on their behalf. Participants who met the inclusion criteria were invited to take part in the study. Informed consent was sought after the aim and method of the study were explained to them. Participants were assessed predischarge.

The Glasgow Coma Scale (GCS) on admission was noted to establish the severity of the TBI (McNett, 2007). The following were also administered: the modified Mini Mental State Examination to establish cognitive ability (Elhan et al., 2005); and the Rivermead Mobility Index to establish functional mobility outcome (Williams, Robertson, & Greenwood, 2004). Thereafter, a self-designed questionnaire (Appendix A) was administered predischarge to determine factors that had an effect on the functional mobility outcome. Literature as well as the opinions of experts in the field of adult neurological rehabilitation was used to establish content validity for this questionnaire. The questionnaire captured demographic information; mechanism of injury; types of brain lesions; length of hospital stay; medical and surgical intervention; availability of a caregiver; employment status; the number of financial dependants; premorbid lifestyle and health status; bowel and bladder continence; ability to speak; complications experienced postinjury; whether they received physiotherapy, occupational therapy, or speech therapy while in hospital; and the number of rehabilitation sessions received (this was determined from the medical records). All data were collected by registered physiotherapists.

Statistical analysis was performed using STATISTICA version 9 (Statssoft Company, Tulsa, Oklahoma, USA). Descriptive statistics were used to describe the participants' characteristics and the GCS, Rivermead Mobility Index, and modified Mini Mental State Examination scores. A multiple regression analysis was done, however, in order to prevent the multivariate analysis from being limited, all variables were included in the analysis and this ensured that these were analysed against each other and the most significant variables were determined. Functional mobility outcome was a dependent variable and the rest of the variables were entered into the regression analysis as independent variables. By convention, 10—15 participants should be included in the study for every factor that enters the regression analysis (Nunally, 1978). From the literature, not more than six factors were established to have an influence on functional outcome after TBI and hence a sample size of a minimum of 60 participants was required for this study.

Results

The sample consisted of 56 males (93%) and four females (7%). The average age of the participants in this study was 28 ± 8.5 years, with 50% of the participants being between the ages of 20 years and 29 years. Details pertaining to the general characteristics of participants in the study are shown in Table 1. The most common mechanism of injury was assault (43, 72%), followed by motor vehicle accidents (11, 18%), and the least common mechanism was falls (1, 2%). The average length of hospital stay was 17 ± 15.9 days with a minimum of 3 days and maximum of 72 days. More

Table 1 Details of the General Characteristics of Participants in the Study ($n = 60$).

Patient detail	Factor	n (%)
Level of education	None	2 (3)
	Up to Grade 7	23 (38)
	Up to Grade 11	13 (22)
	Grade 12	19 (32)
	Grade 12 + 3 years	3 (5)
Marital status	Single	38 (63)
	Married	5 (9)
	Cohabitating	17 (28)
Employment status	Employed	25 (42)
	Self employed	14 (23)
	Unemployed	9 (15)
	Other	12 (20)
Income ($n = 59$)	R0 ($0)–R800 ($97.5)	26 (44)
	R801 ($97.7)–R2000 ($243.8)	21 (36)
	R2001 ($244)–R5000 ($610.6)	8 (14)
	Above R5000 ($610.6)	4 (6)
Lifestyle ($n = 52$)	Smoking	2 (4)
	Drinking	14 (27)
	Smoking and drinking	36 (69)
Availability of caregiver	Lives alone	4 (7)
	Caregiver during day	1 (2)
	Caregiver at night	15 (25)
	Caregiver all the time	40 (66)
Lesion	Contusion	23 (38)
	Extradural haematoma	16 (27)
	Subarachnoid haematoma	14 (23)
	Subdural haematoma	14 (23)
	Intracerebral lesion	11 (18)
	Skull fracture	9 (15)
	Diffuse axonal injury	4 (7)
	Intraventricular haemorrhage	3 (5)
	Pneumocephalus	2 (3)
	Cerebral oedema	2 (5.6)
	Rhabdomyolysis	1 (2)
	Infarct	1 (2)
	Hypodensity	1 (2)

than 50% of the participants had more than one type of lesion. The most common lesion incurred was contusion (38%).

Participants received on average 5 ± 5.6 physiotherapy sessions, 2 ± 3.5 occupational therapy sessions, and 2 ± 2.7 speech therapy sessions. Table 2 displays the scores indicating severity of injury. The GCS scores are separated in the table as some participants were scored out of 15 on admission, whereas those who were intubated on admission were scored out of 10. A score out of 10 eliminates the verbal component of the GCS. Due to problems with filing at the respective hospitals, the GCS on admission was not noted in three of the participants' hospital files; therefore, $n = 57$ for GCS scores. The average Rivermead Mobility Index score was 8/15 indicating that patients were generally able to walk indoors with assistance at discharge.

Table 2 Summary of Scores Indicating Severity of Injury ($n = 60$).

Score	Mean ± standard deviation
Glasgow Coma Scale (/15; $n = 50$)	11 ± 4.1
Glasgow Coma Scale (/10; $n = 7$)	6 ± 2
Rivermead Mobility Index	8 ± 5.3
Modified Mini Mental State Examination	13 ± 7.1

Table 3 shows the functional mobility outcomes at discharge from the hospital. More than 50% of the participants were unable to walk outside and 37% were able to climb a flight of stairs without help at the time of discharge from the hospital.

The type of medical intervention that the participants received was as follows: 28 participants (47%) did not undergo surgery and/or receive medication (were just observed); 17 (28%) underwent a craniotomy; 15 (25%) received medication in the form of Mannitol (a diuretic used to decrease the intracranial pressure as well as cerebral oedema); two (3%) underwent craniotomy and also had Mannitol and one (2%) underwent craniectomy.

Table 4 shows factors that had an influence on functional mobility outcome. For each year older, a person was on average 0.94 times as likely to be functionally mobile on discharge ($p < .001$). Participants that had craniotomy were on average 0.29 times as likely to have functional mobility on discharge as compared to those who had no surgery and received no medication ($p < .001$). For every increase in the unit of occupational therapy sessions that patients had, their functional mobility increased by 1.11 ($p = .002$).

Discussion

The main aim of this study was to determine factors that have an influence on functional mobility outcomes of people with TBI at the time of discharge from the hospital. Half of the participants in this study were young adults (age 20–29 years) and 56 (93.3%) were males. This is not surprising as males are at a higher risk of sustaining TBI than females. This finding is similar to that of Bruns and Hauser (2003) who established the male to female ratio of TBI sufferers to be 4:1. Faul, Xu, Wald, and Coronado (2010) also established that in the USA, in every age group, TBI rates are higher for males than for females [10]. Similarly, Chua et al. (2007) also found that males are approximately 3–4 times more likely to sustain a TBI.

More than 50% of the participants were unable to walk outside and 37% were able to climb a flight of stairs without help at the time of discharge from the hospital. The lack of mobility by about half of the participants can be attributed to the high number of those who suffered cerebral contusions (38%), which are indicative of moderate to severe lesions (Englander et al., 2003). The average GCS score of the participants (11/15) also indicates that most of them could have had moderate lesions as a score of 9–12 indicates moderate brain lesions and that < 9 indicates severe lesions (Bruns and Hauser, 2003). Another reason for

Table 3 The Functional Mobility Outcomes from the Rivermead Mobility Index Scores ($n = 60$).

Activity	n (%)
Rolling (turning from back to side without help)	55 (92)
Lying-to-sitting on edge of the bed without holding	49 (82)
Sitting balanced on edge of bed for 10 seconds without holding	50 (83)
Sit-to-stand using hands or an aid if necessary	44 (73)
Standing balance without any aid or support	38 (63)
Transfer (e.g., from bed to chair and back without help)	37 (62)
Walking inside with assistive device	30 (50)
Stairs (flight of stairs without help)	22 (37)
Walking outside	22 (37)
Walking inside with no aid	24 (40)
Picking up object from floor	22 (37)
Walking on uneven ground without help	19 (32)
Bathing (bath or shower unsupervised)	17 (28)
Climbing four steps with no rail and without help, but using an aid if necessary	19 (32)
Running/walking 10 m without limping in 4 seconds	9 (15)

poor mobility of participants in this study could be that in addition to them having severe lesions, the average length of hospital stay was also short (17 $\pm$ 15.9 days), and thus not allowing enough time for recovery and rehabilitation prior to discharge.

Age was also found to have an influence on functional mobility. For each additional year to a person's age, they were on average 0.94 times as likely to be functionally mobile at the time of discharge. Hukkelhoven et al. (2003) also established that older age is continuously associated with a worsening outcome after TBI. This finding is also similar to that of Englander et al. (2003) who established that age assists in determining functional outcome. This could possibly be due to reduced strength and hence function with ageing or reduced chances of neural plasticity as one gets older.

Gender was also found to have an influence on functional mobility. This study found that males had on average 2.95 times more functional mobility on discharge when compared to females ($p = .001$). Not much research has been conducted looking at the physiological differences in recovery between males and females. Chua et al. (2007) found that the severity and mortality rate was higher in males compared to females due to lifestyle differences as well as the differences in exposure to risk taking behaviour, which contradicts the findings of this study. However, a meta-analysis by Farace and Alves (2000) had findings that are similar to our study suggesting that men have better outcomes than women. This is generally the opposite pattern of what is found in literature. In our study, a comparison was made between only four female patients and 56 male patients, and thus the results may not be reliable due to the big difference in the number of patients within each category.

Participants who had a Grade 12 level of education were on average 2.04 times more likely to be mobile on discharge ($p = .001$) when compared to those that never attended school. This finding is similar to that of Mushkudiani et al. (2007) who found that highly educated patients (with >12 years of education) have a more favourable outcome compared to those with a lower education level. This was further reiterated by Jeon et al. (2008) who found that higher educational level and intelligence may preserve the cognitive function of a patient regardless of the severity of the injury.

Participants who were self employed were 4.03 times more likely to have better functional mobility ($p < .001$) as

Table 4 Factors With an Influence on Functional Mobility Outcome.

Factor	Sqrt (β)	Standard error	T	$p >$ ltl	95% confidence interval
Age (y)	0.94	0.01	−4.84	<.001	0.92–0.97
Gender. Reference: female					
Male	2.95	0.88	3.62	.001	1.61–5.41
Education. Reference: never attended school					
Grade 12	2.04	0.41	3.56	.001	1.36–3.07
Employment status. Reference: employed					
Unemployed	3.93	1.03	5.23	<.001	2.31–6.7
Self employed	4.03	0.9	6.26	<.001	2.57–6.34
Income. Reference: R0–R800					
R801 (\$97.7)–R2000 (\$243.8)	2.05	0.39	3.79	.001	1.39–3.01
> R5000 (\$610.6)	6.35	1.99	5.87	<.001	3.35–12.04
Lifestyle. Reference: no smoking or drinking					
Premorbid smoking and drinking	0.52	0.87	−3.90	<.001	0.37–0.73
Continence. Reference: incontinent					
Bowel and bladder continence	3.80	0.73	6.98	<.001	2.58–5.61
Occupational therapy sessions	1.11	0.04	3.43	.002	1.04–0.19
Treatment. Reference: no medication & no surgery					
Medication	0.53	0.98	−3.41	.002	0.37–0.78
Craniotomy	0.29	0.61	−5.85	<.001	0.19–0.44

$|t| = t$ value.

compared to those that were employed. A reason for this could be that those who were self employed did not have sick leave and thus may have focused more to regain function quickly in order to generate an income. Those who were employed may not feel the pressure to regain function as some of them may have had an income while on sick leave as per the South African Basic Conditions of Employment Act: No. 75 of 1997.

Participants who were continent with both bowel and bladder were found on average to be 3.8 times more likely to be functionally mobile than those who were incontinent ($p < .001$). Not many studies look at the frequency of urinary and faecal incontinence in people with TBI. Safaz, Alaca, Yasar, Tok, and Yilmaz (2008) reported that people with urinary and faecal incontinence have poorer cognitive outcomes when compared to those who are continent. Patel, Coshall, Rudd, and Wolfe (2001) found that urinary incontinence was associated with muscle weakness and in a multivariate analysis found it to be a strong predictor of death or disability at 2 years after TBI. This confirms that the presence of incontinence is related to a possible decrease in physical functional ability.

Sixty-nine percent of the participants in this study were smokers and drank alcohol. Functional mobility on discharge of those who smoked and drank alcohol was, on average, 0.52 that of those who did not ($p < .001$). This may be due to brain structural and blood flow abnormalities associated with chronic smoking (Meyerhof, 2005). However, not much research has been conducted to determine the effects of smoking and alcohol on recovery after TBI.

Patients who underwent surgery (craniotomy) were 0.29 times as likely to be mobile on discharge ($p < .001$) compared to those patients that had no surgery and no medication. The interventions carried out on patients that were included in this study were specific to the type and severity of the lesion as well as the availability of investigation procedures (computed tomography scan) and theatres for surgery at the hospitals included in this study. In addition, the option of surgery as an intervention was decided by the doctor together with the senior consultant at the respective hospitals included in this study. The reason craniotomy had a negative influence on functional mobility outcome may be that patients requiring this intervention are likely to have had more severe injuries as compared to patients requiring no surgery and no medication. Timofeev and Hutchinson (2006) stated that decompressive surgery is opted for when other measures of controlling intracranial pressure have been exhausted and is used as an alternative and/or an addition to medication.

This study found that receiving occupational therapy is significantly related to mobility. This contradicts the study by Heinemann, Hamilton, Linacre, Wright, and Granger (1995), who found that the intensity of occupational therapy was not related to motor outcomes. However, Teasell and Kalra (2005) have shown that participating in therapy results in improvements in function, in line with our findings.

Limitations

The main limitation in this study was being unable to transform the data obtained from the GCS scores. This was due to the fact that some of the patients' were scored out of 15, whereas those patients that were intubated on admission were scored out of 10. Thus, the researcher together with the statistician was unable to include the GCS scores in the final multivariate analysis. The sample size of 60 was based on six possible factors that would influence function (based on literature review); however, seven factors were found to influence function in this study. Thus the minimum sample size should have been 70 participants with TBI.

Conclusion

Previous studies have identified a multitude of factors and this study has served to confirm that some of the aforementioned factors are significant to functional outcome after TBI. Younger age, male gender, Grade 12 education, being self employed, having both bowel and bladder continence, not smoking and drinking, and occupational therapy sessions have a positive impact on the physical function after TBI.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.hkjot.2013.08.001.